Design and Construction of a Trolley with 360 Degree Rotation

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Abstract: The purpose of this undertaking is to develop and fabricate a three-axis rotating trailer that incorporates a pneumatic system in order to overcome obstacles that may arise while unloading materials. Difficulties in emptying materials from containers, including restricted directional emptying and obstacles in confined spaces, were identified through our research. As a result, the design of our trailer permits the discharge of materials from all three sides, thereby increasing efficiency. Compressed air is stored in a compressor engine that is linked to the engine propulsion of the vehicle as part of the pneumatic system. The discharge of materials is facilitated by the pneumatic cylinder, which is activated by the valve. Furthermore, the implementation of spur gearing facilitates three-directional rotation of the trailer, which clarifies the process of unloading cargo in confined spaces. This technological advancement holds the potential to optimize the efficiency and adaptability of material transportation, specifically in confined urban setting.

Key words: Design, Fabrication, Pneumatic cylinder, Three direction rotation.

1. INTRODUCTION

Trailer technology is extensively utilized in numerous industries, including construction, waste management, and agriculture. Conventional trailers are constrained in their ability to exclusively discharge materials from the rear, which presents considerable difficulties when navigating through confined spaces and narrow lanes while unloading [1]. In order to overcome this constraint, a multidirectional...
carriage system is devised that utilizes a solitary actuator and permits the discharge of materials in various directions [2]. In contrast to traditional trailers, which are limited to discharging in a single direction, the multidirectional trailer system effectively addresses spatial limitations, resulting in decreased road obstructions and improved operational efficiency [3]. Particularly in confined spaces, such as mines, this novel configuration, referred to as a "Three-Way Trailer," permits material dispersal in three different directions; thus, it maximizes space utilization and reduces fuel and time consumption [4]. In order to enhance the effectiveness of tilting regarding these particulars, a pneumatic system is utilized. By virtue of its utilization of compressed air, the pneumatic chamber surmounts the constraints of single-sided dumping mechanisms and permits controlled dumping in multiple directions [5]. The objective of the project is to optimize operational control and efficiency by integrating direction control valves and flow control valves in order to precisely regulate the passage of air and fluid within the system [6].

2. LITERATURE REVIEW

The objective of the project by Ajithkumar, P., Dhivya, D., and Surendar, D. is to integrate microcontrollers with pneumatic mechanisms in order to increase the efficacy of dumping trailers. This novel methodology facilitates the unloading of materials in three distinct orientations, specifically designed to meet the demands of the shipping sector [7]. Utilizing the synergistic functionalities of microcontrollers and pneumatics, the undertaking endeavors to diminish needs for both labor and time. Dr. Sushila Rani stresses the critical importance of effective dumping when it comes to managing heavy construction burdens [8]. In an effort to overcome obstacles associated with material offloading, we propose modified designs that integrate chain sprocket systems and pneumatic cylinders [9]. By employing finite element analysis in conjunction with the ANSYS software, a dumper design is formulated that guarantees both optimal functionality and accurate material positioning on construction sites [10].

3. METHODOLOGY

The initial iteration of dump trucks, which emerged prior to the year 1900, consisted of uncomplicated two-wheeled carts hauled by horses. When unlatched, these wagons, which were loaded with goods, could be dumped via the axle hinge. They were frequently employed in open mines and were propelled by horses along railroad lines. Subsequently, approximately in the year 1900, a four-wheeled flatbed carriage materialized, boasting a rectangular body elevated by hand from the front. In the pre-modern era, materials were extracted and conveyed through the utilization of trolleys and locomotives, including box tip wagons and scoop tippers, as recorded by Heinz-Herbert Cohrs in his work "500 Years of Earthmoving".
3.1. Early Truck Mounted Dump Bodies

For disposal, early prototypes of truck-mounted dump bodies utilized gravity. These designs incorporated an off-center fulcrum point that secured the body in a level position. When the lock was unlocked, the body could be emptied in reverse, but it remained securely fastened when not in use. Subsequent to the Mann gravity dump’s 1904 introduction, English-made trucks were manufactured integrating this design principle.

3.2. Hydraulic Dump Bodies

Early on, dump bodies affixed on trucks were equipped with hydraulic systems. Among the earliest examples, the Robertson Steam Wagon was distinguished by its hydraulic hoist, which was either propelled by the truck’s engine or an independent steam engine. 1907 saw the invention of an additional steam-powered hydraulic dump body by Glasgow’s Alley & McLellan, which was intended to elevate the body to facilitate material movement along chutes. The elevation of the dump body was achieved through the utilization of four screws that were actuated through the power take-off of the truck. The implementation of a gravity pitch would facilitate the seamless movement of coal from the hopper to the conveyor, thereby enhancing the efficiency of material discharge.

3.3. Crawler Tractor-Trailer

Crawler tractors, which towed sizable dump trailers on tracks or wheels, gained prominence by the mid-1920s. At one time, these crawlers could propel between two and five containers. Wagons, originally constructed for attachment to crawler vehicles, were initially affixed to tracks. Later, in order to circumvent speed restrictions, they were remounted on wheels to enhance their velocity. Prominent producers of these trailers and transporters included James Hagy, LaPlant-Choate, Rex-Watson, Streich, and Western, among others.

3.4. Euclid Dump Trucks

George Armington Jr., the progeny of the organization’s founder and a pioneer in the development of dump vehicles, contributed significantly to the field as a hydraulics designer. With the development of the modern heavy-duty off-road vehicle and the wheel tractor bottom dump wagon, he contributed significantly to the industry. The year 1934 marked the introduction of the ”TrakTruk,” a dump vehicle with a capacity of 10/11 tons, which cemented Euclid’s status as a pioneer in the industry.

3.5. Dump Trucks in the 1950s

Dump vehicles had attained their pinnacle of technological progress by the 1940s. In the 1950s, bottom dump vehicles became a common sight on construction sites involving earthwork in the United States. As a result of the construction industry’s transition from rail to road material conveyance, domestically manufactured construction site tippers were in greater demand. At the time, Faun was one of the
most notable manufacturers of heavy-duty dump trucks. The vehicles manufactured by them were instrumental in fulfilling the escalating requirements of construction endeavors, thereby exemplifying the sector’s progression towards more streamlined and adaptable modes of transportation.

3.6. Saint John First
The dump truck was initially conceptualized and developed in 1920 by Saint John, New Brunswick’s Robert T. Mawhinney, who affixed a dump box to a flat-bed vehicle. A winch was linked to a cable that traversed a pulley situated on a mast behind the cockpit as the lifting mechanism. The cable was affixed to the wooden dump box’s lower front end, which rotated at the rear of the vehicle frame. With his groundbreaking design, Mawhinney established the groundwork for the contemporary dump truck, which brought about a paradigm shift in the transportation and construction sectors.

4. CAD MODEL
The CAD design of the proposed model is shown in Figure 1.

![CAD Design of the Proposed System](image)

**Figure 1.** CAD Design of the Proposed System

5. DESIGN CALCULATION
**Double Acting Cylinder Calculator for Output Stroke:**
The force exerted by a double acting pneumatic cylinder can be expressed as:
\[ F = \frac{p}{A} \]
F = pπd_{2}/4
where, F = force exerted (N)
p = gauge pressure (N/m^{2}, P_{a})
A = full bore area (m^{2})
d = full bore piston diameter (m)

**Double Acting Cylinder Calculator for Input Stroke:**
The force exerted by double acting pneumatic cylinder on outstroke can be expressed as follow:
The force exerted on in stroke can be expressed as
\[ F = p\pi \left( d_{1}^{2} - d_{2}^{2} \right) / 4 \]

**Calculation for Double Acting Piston Outstroke:**
A single acting pneumatic cylinder at 1 bar ([10]^{5} N/m^{2}) and full pressure bore diameter of 10mm (0.01 m) can be calculated as:
Area of Cylinder (A) = \pi / 4 \times (d)^{2}
= 3.14 / 4 \times (0.025)^{2}
= 4.906 \times [10]^{-4} \ m^{2}
F = p / A
= 78.45 \times [10]^{-4} / 4 \times 4.906 \times [10]^{-4}
F = 15.99 \ N

**Calculation-Double Acting Piston in-Stroke:**
The force exerted from a single acting pneumatic cylinder with 8kg/cm2 7.84bar full bore diameter of 25 mm (0.025 m) and rod diameter 10 mm (0.01 m) can be calculated as:
F = p / \pi \left( d_{1}^{2} - d_{2}^{2} \right) / 4
= (78.45 \times [10]^{-4}) / \pi \left( (0.025)^{2} - (0.01)^{2} \right) / 4
F = 19.02 N

Volume of the Cylinder (V) = Area of Piston \times \text{Stoke Length}
= \pi / 4 \times d^{2} \times 100 \ m
= \pi / 4 \times (0.01)^{2} \times 0.1
V = 7.85 \times [10]^{-6} \ m^{3}

**6. EXPERIMENTAL RESULTS**
The research project aimed to develop and construct a three-axis rotating trailer equipped with a pneumatic system to address challenges encountered during material unloading. Difficulties in emptying materials from containers, including restricted directional emptying and obstacles in confined spaces, were identified through our research. As a result, the design of our trailer permits the
discharge of materials from all three sides, thereby increasing efficiency. Compressed air is stored in a compressor engine that is linked to the engine propulsion of the vehicle as part of the pneumatic system. The discharge of materials is facilitated by the pneumatic cylinder, which is activated by the valve. Furthermore, the implementation of spur gearing facilitates three-directional rotation of the trailer, which clarifies the process of unloading cargo in confined spaces. This technological advancement holds the potential to optimize the efficiency and adaptability of material transportation, specifically in confined urban settings.

![Hardware Implementation](image)

**Figure 2. Hardware Implementation**

7. **CONCLUSION AND FUTURESCOPE**

This study describes the conception and construction of a sophisticated three-axis pneumatic trailer with the intention of promoting the adoption of modern pneumatic trailer technology by providing user-friendly and efficient machinery. The system that was developed provides cost-effective automation and easy operation, rendering it suitable for a wide range of applications. By conducting extensive testing that encompasses evaluations of speed, power, efficiency, and efficiency, the system exhibits a marked improvement in performance when compared to currently available discharge mechanisms. A lead screw mechanism for rolling shutters, a chain drive mechanism, MS Sheet, MS Square Pipe, Polished Rod, a double acting pneumatic cylinder, a universal joint, pneumatic pipes, a directional control valve, pneumatic fluid, a pneumatic pump, and a reservoir are essential construction components. The construction procedure entails the utilization of MS Square Pipe to assemble a robust frame, MS Sheet to fabricate the trailer body, and pneumatic conduits to connect a double-acting pneumatic
cylinder for the purpose of operation. The reservoir, directional control valve, and pneumatic pump all contribute to the efficient operation of the system, while the chain drive mechanism permits the load-bearing structure to rotate. In its entirety, this pneumatic trailer configuration exemplifies the multipurpose capabilities, optimal performance, and flexibility of pneumatic technology as it pertains to contemporary automation systems and apparatus.

References


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